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GSC 02693-00926 and USNO-B1.0 1587-0201409, Two New Doubly Eclipsing Systems

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I present my detection of two new doubly eclipsing systems, GSC 02693–00926 and USNO-B1.0 1587–0201409 (types EA+EB and EB+ELL). I analyzed all observations available for these stars in the NSVS and ASAS-SN online public archives using the period-search software developed by Dr. V.P. Goranskij for Windows environment. The light elements of both variations and the parameters of light curves are obtained.

1 Introduction

The AAVSO/VSX database contains information on about two dozens of Galactic double-period eclipsing variables (doubly eclipsing systems). Among them, there are 11 doubly eclipsing systems found by Pietrukowicz et al. (2013) in the OGLE-III galactic-disk fields. An interesting case of a two-period eclipsing binary, CzeV343, was discovered by Cagaš & Pejcha (2012). Also, Soszyński et al. (2016) found several dozens of stars in the galactic bulge with simultaneously visible two superimposed eclipsing or ellipsoidal variations.

I studied two variable stars, GSC 02693–00926 and USNO-B1.0 1587–0201409, using available photometric archive data: the Northern Sky Variability Survey[1] (NSVS, Woźniak et al. 2004) and the All-Sky Automated Survey for Supernovae[2] (ASAS-SN, Shappe et al. 2014; Kochanek et al. 2017). I analyzed all the observations using Deeming's method (Deeming 1975) and Lafler–Kinman method (Lafler & Kinman 1965) implemented in the WinEfk code[3] written by V.P. Goranskij. Both stars show double periodicity typical of the doubly eclipsing systems. In these cases, the double periodicity cannot be explained with a blend of two variable sources. Both stars are single photometric objects, very well identified in the ASAS-SN data. Figure 1 presents the finding charts.

The data files from the ASAS-SN and NSVS observations are available online in the html version of this paper as a zip-archive.

[1] http://skydot.lanl.gov/nsvs/nsvs.php
[2] https://asas-sn.osu.edu
[3] http://www.vgoranskij.net/software/

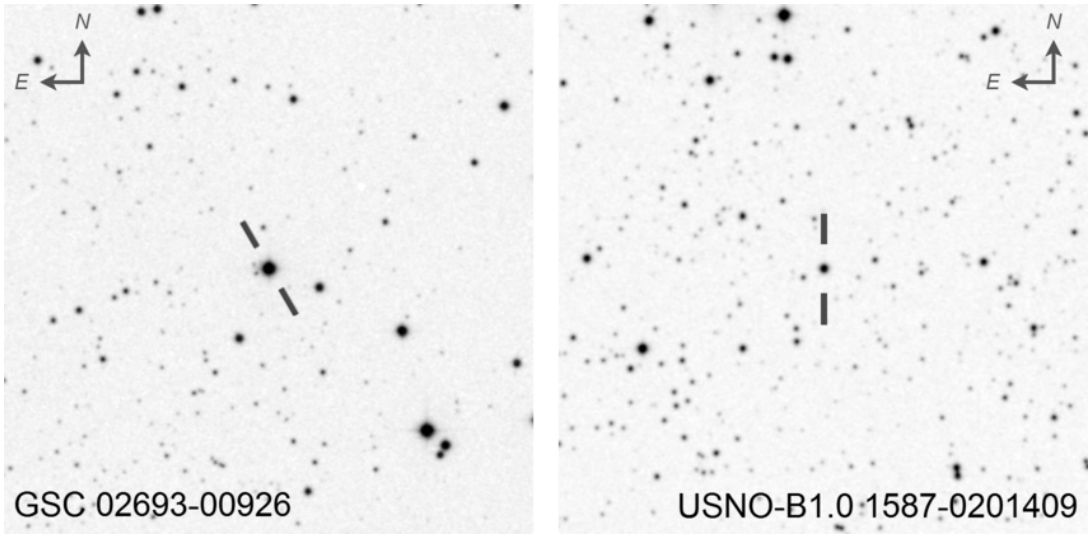

Figure 1.
The finding charts of the two variables (from POSS blue plates). The size of each chart is $7' \times 7'$.

2 GSC 02693–00926

The variability of GSC 02693–00926 ($\alpha = 20^{\rm h}26^{\rm m}43\overset{\rm s}{.}83$, $\delta = +35°20'30\overset{''}{.}0$, J2000; NSVS 8506511) was suspected in 2008 by J.S. Shaw et al. in the course of their automatic analysis of NSVS data (see the unpublished list of suspected variables[4]); they give the automatically detected possible periods, $0\overset{\rm d}{.}67527130$ or $0\overset{\rm d}{.}67517677$, and do not suggest any variability type. We suspected this variable to be a double-mode RR Lyrae star on the base of NSVS data. Later, I analyzed the ASAS-SN data, which showed that the variable actually was a doubly eclipsing star, EA+EB type according to the classification of the GCVS(Samus et al. 2017).

The system's color indices are $J - K = 0.33$ (2MASS), $B - V = 0.67$ (Tycho-2), $B - V = 0.70$ (APASS). Possibly, the amplitude in the NSVS data is slightly underestimated because of the influence of the nearby star GSC 02693–00142 at the distance $d = 43''$; this star is rather red, $B - V = 1.44$ (APASS) and $J - K = 0.80$ (2MASS), and has a considerable proper motion.

The light elements of the detected variations are:

Component 1 (EA type):

$$\mathrm{HJD(min)} = 2457600.760 + 1\overset{\rm d}{.}350447 \times E;$$

Component 2 (EB type):

$$\mathrm{HJD(min)} = 2457600.808 + 1\overset{\rm d}{.}099203 \times E.$$

The range of variability in the ASAS-SN data is $11\overset{\rm m}{.}61 - 12\overset{\rm m}{.}03$ (V) and in the NSVS data, $11\overset{\rm m}{.}6 - 11\overset{\rm m}{.}85$ (R). For component 1, the eclipse duration is $D = 0\overset{\rm p}{.}22$. Component 2 clearly exhibits the O'Connell effect. The depths of minima of GSC 02693–00926 are presented in Table 1. Additionally, for the second variability component, Table 1 gives the difference of maximum heights, ΔMax. The light curves according to ASAS-SN and NSVS data are displayed in Figs. 2 and 3.

[4] http://www.physast.uga.edu/~jss/nsvs/untyped.cat.Z

Table 1. The depths of minima of GSC 02693-00926

		V Δmag (ASAS-SN)	R Δmag (NSVS)
Component 1	MinI	0.20	0.16:
	MinII	0.16	0.13
Component 2	MinI	0.20	0.15
	MinII	0.17	0.13
	ΔMax	0.04	0.04

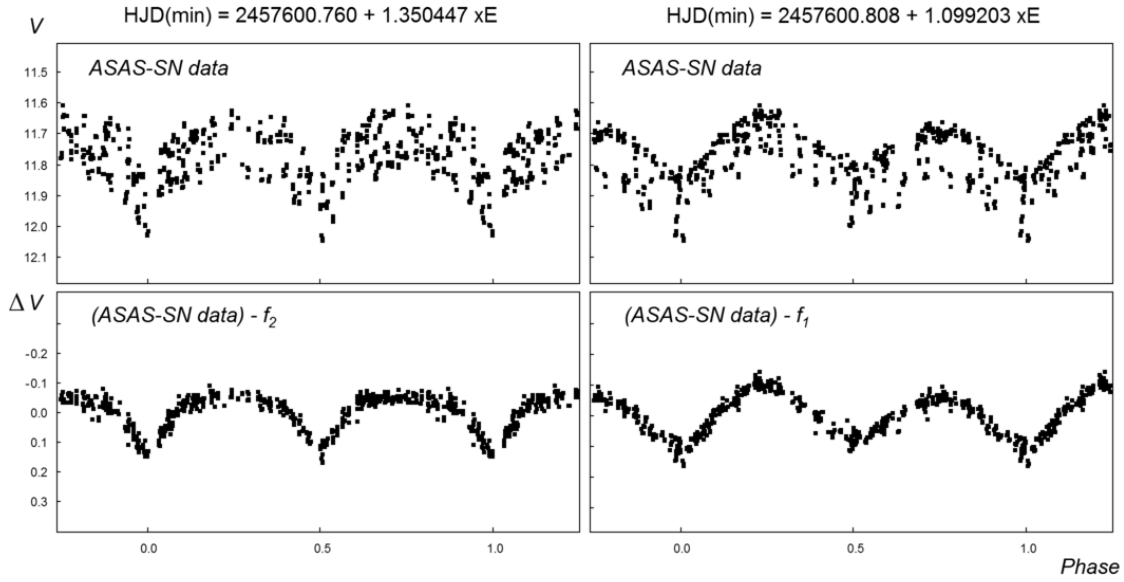

Figure 2.
The light curves of GSC 02693-00926 according to ASAS-SN data.

3 USNO-B1.0 1587–0201409

The variability of USNO-B1.0 1587–0201409 ($\alpha = 22^{\rm h}31^{\rm m}41\overset{\rm s}{.}96$, $\delta = +68^\circ46'22\overset{''}{.}3$, J2000; NSVS 154567) was discovered by Hoffman et al. (2009) from NSVS data. They give the period $5\overset{\rm p}{.}71434$ days and type CEP (cepheid / long period variable candidates). This star is actually a double-periodic variable. I classified USNO-B1.0 1587–0201409 as a possible doubly eclipsing system: the first component is an eclipsing system (type EB), the second component shows the variability typical of ellipsoidal variable stars (type ELL).

The light elements of the detected variations are:

Component 1 (EB type):

$$\mathrm{HJD(min)} = 2457604.46 + 11\overset{\rm d}{.}4838 \times E;$$

Component 2 (ELL type):

$$\mathrm{HJD(min)} = 2457602.44 + 2\overset{\rm d}{.}93956 \times E.$$

The variability range in the ASAS-SN data is $13\overset{\rm m}{.}19 - 13\overset{\rm m}{.}90$ (V); in the NSVS data, it is $12\overset{\rm m}{.}8 - 13\overset{\rm m}{.}25$ (R). In our data analysis, the trend to slow brightness decrease (full

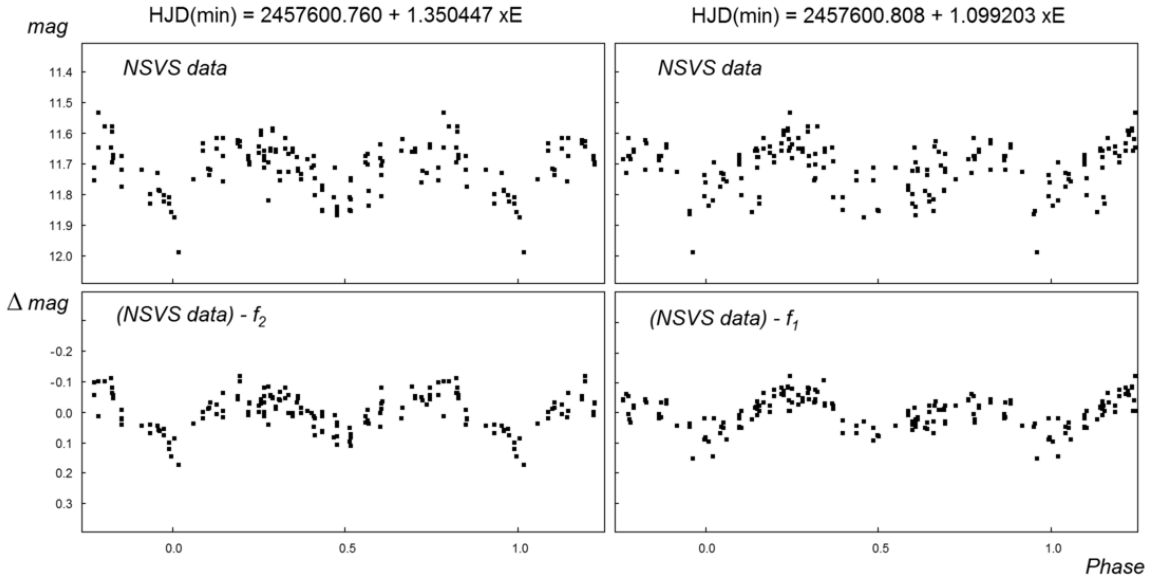

Figure 3.
The light curves of GSC 02693-00926 according to NSVS data. Data with error $> 0\overset{m}{.}1$ are not plotted.

amplitude $0\overset{m}{.}15$) in the ASAS-SN observations was removed. The depths of minima of USNO-B1.0 1587–0201409 are presented in Table 2. The light curves according to ASAS-SN and NSVS data are displayed in Figs. 4 and 5.

Table 2. The depths of minima of USNO-B1.0 1587–0201409

		V Δmag (ASAS-SN)	R Δmag (NSVS)
Component 1	MinI	0.25	0.17
	MinII	0.22	0.15
Component 2	MinI	0.18	0.09
	MinII	0.16	0.07

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The eclipsing nature of this system is confirmed with different depths of brightness minima, which is established confidently, though, in this case, larger photometric errors make the difference less obvious than in the case of GSC 02693–00926.

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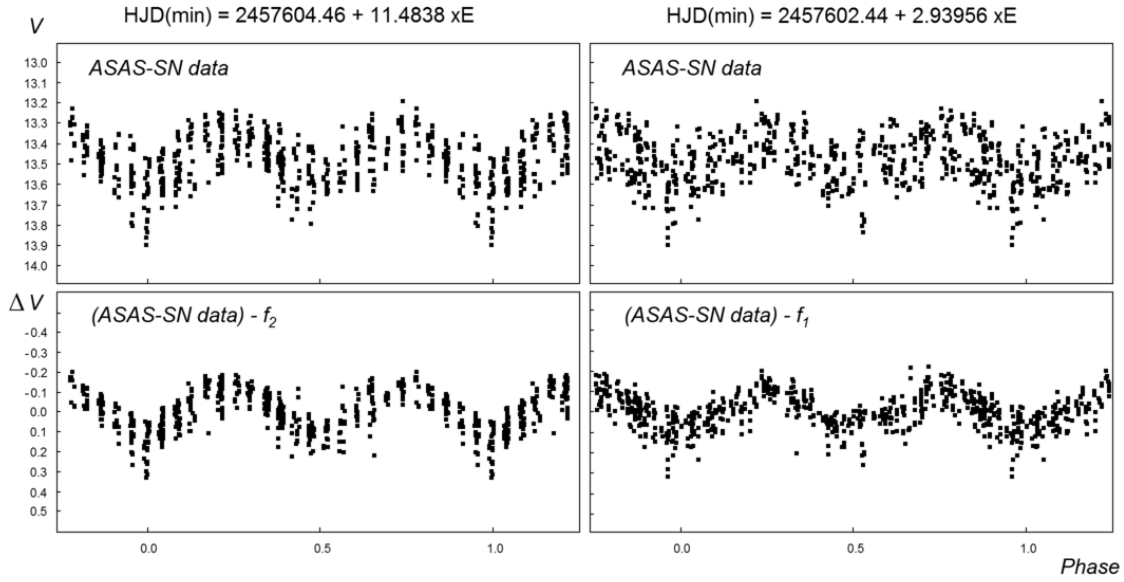

Figure 4.
The light curves of USNO-B1.0 1587-0201409 according to ASAS-SN data.

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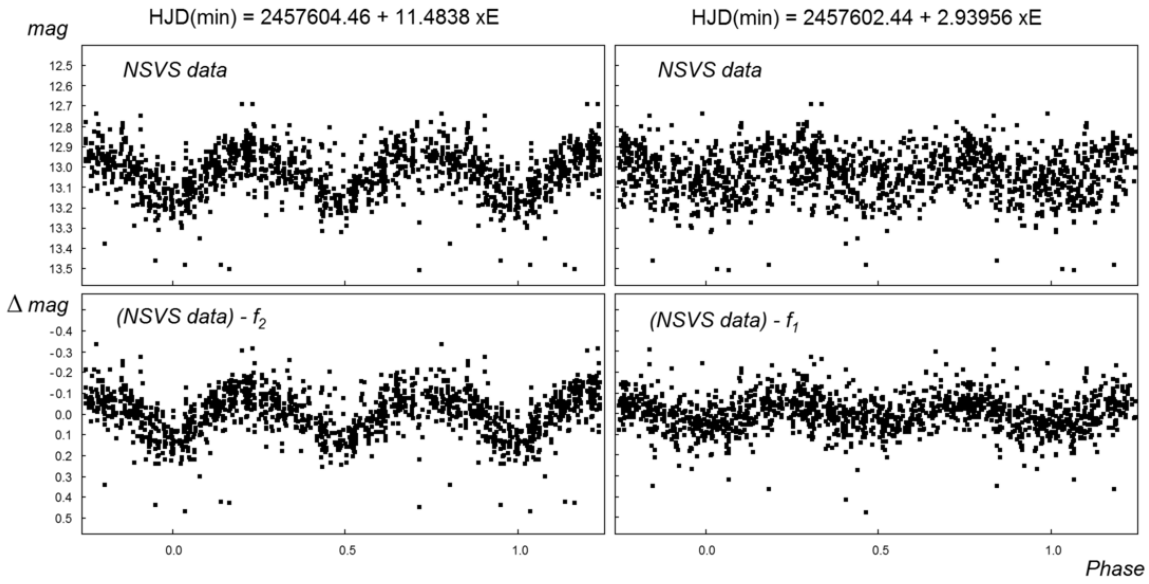

Figure 5.
The light curves of USNO-B1.0 1587-0201409 according to NSVS data.